Budapest University of Technology and Economics
Faculty of Architecture
Department of Mechanics, Materials and Structures

QUESTIONS OF THE GLOBAL EXAMINATION, ORAL PART

2019. 05.16.

STRENGTH OF MATERIALS I.

1. What is the definition of a rigid object/body; a solid object/body and an elastic and plastic object/body? When do we use these approximations? What is the Bernoulli-Navier Hypothesis? In which situations do we accept this hypothesis? When is it not acceptable?

2. What is the meaning of „homogenous" and „isotropic" material? Which one of these properties is satisfied by common structural materials? What is *Hooke's Law*? Define the symbols in the formula, give also their units. What are the limits of the application of the law?

3. Give a sketch of the real *stress-strain* (i.e. σ -ε) *diagram* in the case of steel material. Explain Young's modulus; specify the characteristic points of the diagram. How do we idealize this for computations?

4. How and when can we use „linear superposition" for the calculation of stresses, internal forces or deformations?

5. Give definition of the *stress*. What is the difference between the normal and shear stresses? Give the definitions of *yield strength*, *ultimate strength*, *design strength and design stress.*

6. What is *simple tension and simple compression*? How are the stresses due to simple tension calculated? How can we find the stresses in the case of an inhomogeneous bar (e.g. concrete + reinforcement)? What is the difference between the analysis due to simple tension and simple compression?

7. What do we mean by the „stress state" of a point? Which are the special types of stress states that we may find in beams?

8. What is principal stress and the trajectory of principal stresses? Show examples!

9. What is the *moment of inertia* and the *product of inertia* of a cross-section? (Both are needed!) Where do we use these quantities? What are the *principal directions* and the *principal moments of inertia* of a cross-section? (Do not confuse this with question 8!)

10. What do you know about *shear stresses in planes at right angles* (duality of shear stresses)? From which principle has it been deducted? Where have we applied it?

11. What is *pure shear*? What loading type causes pure shear? How are the shear stresses calculated? Which structural elements are analyzed for this kind of stress?

12. Speak about the necessary checks of *riveted or bolted structural joints*.

13. What is *pure bending*? What assumptions are considered in the stress analysis? What is the Bernoulli-Navier Hypothesis? How do we calculate the stresses? What is the difference between *pure bending* and *simple bending*?

14. When do we speak about *symmetrical bending* and when about *unsymmetrical* (or skew) *bending*? Speak about the calculation of bending stresses in both cases and show the stress diagrams.

15. Speak about the process of *plastification* of a beam subject to symmetrical bending (with figures and stress diagrams)

16. Speak about the *shear stresses in a beam subject to bending*. How do we calculate them? On what principle is the formula based?

17. Beams in simple bending: show the shapes of the τ - *stress diagrams* in case of different cross-section shapes. When is the location of the maximal shear stress at the centroid of the cross-section and when not?

18. What is the definition of the *shear center*? For what type of structures is it especially important?

19. What is a *built-up beam*? Speak about the stress-analysis and about the analysis of the connecting elements in the case of these structures,

20. Speak about the combined loading case of *bending with axial loading* (i.e. eccentric loading). What is the definition of the *eccentricity*, if the axial (i.e. normal) force and the bending moment are given? What are the different cases of the analysis, and how can you decide which one should be followed?

21. Speak about the stress analysis of a cross-section subject to *eccentric loading*, in elastic stress state (calculation of the max. stress, location of the neutral axis, shape of the stress diagram). What is the definition and the physical meaning of core of section?

22. Speak about the analysis of a cross-section subject to *eccentric loading*, in plastic stress state (stress diagram, location of the neutral axis, check of the strength).

23. Speak about the analysis of a cross-section subject to *eccentric loading*, in case of *a material with no tensile strength,* considering *elastic stress state*. Explain the different possible cases and the corresponding calculation methods. Give definition of the core of section. (Show the corresponding stress diagrams, the location of the neutral axis, the calculation of the maximum stress).

24. Speak about the analysis of a cross-section subject to *eccentric loading*, in case of *a material with no tensile strength*, considering *plastic stress state*. Explain the shape of the stress diagram, the location of the neutral axis, the check of the strength.

25. What is *torsion*? What kind of stresses are developed in case of torsion? In the case of which cross-sections can we use direct calculation methods, and how can we calculate the stresses? What method do you know for other cross-sectional shapes (membrane analogy, sand pile analogy)?

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STRENGTH OF MATERIALS II.

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1. Classify the structures from the point of view of static determinacy. What is the (exact) definition of „statically determinate structures"? Give simple examples.

2. How can you determine whether a structure is statically determinate, indeterminate or over-determinate? Give the necessary and sufficient condition of static determinacy! In case of indeterminate structures how can you determine the degree of indeterminacy?

3. What are the advantages and disadvantages of the use of statically determinate and indeterminate structures? Give examples.

4. Explain the method of *plastic analysis of structures*. (With figures and stress diagrams). -- What is the plastic hinge, the *local plastic reserve* and *global plastic reserve of load*? What is the difference between the behavior of statically determinate and indeterminate structures?

5. Give definitions for *"buckling", "critical force", "critical stress", and "slenderness".* Explain Euler's formula, and the limits of its validity. How do we consider the buckling effect in the practical design?

6. What is *"buckling length"*? Show the basic cases for different support conditions.

7. What are the definitions of external work and internal work? What is the difference between them?

8. What is the equality of the external and internal works? How can we use it for the determination of deformations?

9. What is the difference between *spontaneous work* and *imposed work*?

10. What is a *virtual (or dummy) load*? Where and how is it used?

11. What is *Maxwell's Theorem*? Where and how is it used?

12. *What method* have we learned for the determination of the *deformations of statically determinate structures?*

13. *What methods* have we learned for the *analysis of statically indeterminate structures*? Compare them. What are the unknown quantities in case of the different methods? Give a simple example.

14. Explain the algorithm and its physical background of the *force method*. Show the steps on a simple (at least two times statically indeterminate) example.

15. Define '*rotational stiffness*'; '*translational/lateral stiffness'*. How can we determine their values? Show one example of the derivation of the stiffness!

16. What is the main idea of the *Displacement Method*? What are the unknowns in this method? (Please note this question is not about the Cross method!)

17. What is the main idea of the *Moment Distribution (i.e. CROSS-) Method*? What is the relation between this method and the Displacement Method?

18. Explain the algorithm of the *Moment Distribution Method* for a no-sway frame. Detail the steps of the solution.

19. How can we decide whether a frame is a *no-sway frame* or a *frame with side-sway*? How can we determine the *number of the unknown translations* (i.e. degree of freedom in side-sway)? Give examples.

20. When can we consider a frame as *symmetrical*? Show the possible simplifications in the cases of *symmetrical and anti-symmetrical loading (or deformation).*

21. Explain the analysis of a statically indeterminate beam or frame in case of the *settlement of one or more supports.*

22. What are the possible *thermal influences* on a building structure? How do we consider their effects on statically indeterminate structures?

23. Compare the *Force-* and the *Displacement Methods.* When is it advantageous to use the first and when the second one.

24. Explain the *influence of the deformation* on the internal forces in the case of members subject to concentric (=simple) and eccentric *compression*. What is the First Order-, and the Second Order Theory? How do standards implement Second Order Theory in the practical design?

25. How could you determine the forces acting on the bracing elements of a single storey building due to horizontal/wind load? Give the definition of the parameters necessary to the calculation!

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